Childhood Leukaemia Near Nuclear Installations

To the Editor:

A recent meta-analysis by Baker and Hoel (2007) documented consistently elevated leukaemia incidence and mortality in children, especially those under age 10 years, near nuclear installations. Although a consistent dose–response association was not found, results suggest more detailed investigation is in order. The report extends an investigation of low-dose radiation exposure and childhood leukaemia risk that began in the late 1950s, when a near-doubling of leukaemia mortality by age 10 years from in utero pelvic X-rays was documented (Stewart *et al*. 1958).

The studies cited by the authors indicate that more current data may be needed. Of the 17 studies in the meta-analysis, 12 were published before 1994, raising the question of whether the findings accurately represent present patterns of childhood leukaemia. Only one study examined US nuclear plants, even though the USA is home to nearly one-fourth of all nuclear power reactors worldwide. This report examined cancer mortality rates near US plants that began operating before 1982, before and after startup, but ended with 1984 data (Jablon *et al*. 1991). The availability of historical mortality data on the US Centers for Disease Control and Prevention web site makes an update of this study feasible. The prior study, conducted by the US National Cancer Institute, presented mortality data for childhood leukaemia (age 0–9 and 10–19 years) near 51 US nuclear power plants. It used a Standard Mortality Ratio (SMR), defined as the proportion of the local to national death rate, to analyse temporal changes near nuclear plants after startup. (The one or two closest counties to each plant were selected as the local area.) It is now possible to observe any changes in SMR for childhood leukaemia as nuclear plants age. Table 1 compares the ratio for the year after startup through 1984 to the period 1985–2004. The 51 plants are also divided into three categories: older plants (startup from 1957 to 1970 and still operating), newer plants (startup from 1971 to 1981 and still operating) and plants permanently closed. The local areas constitute a total of 67 counties, with a current population of about 25 million, or 8% of the US total.

We observe a uniform pattern of increase in childhood leukaemia SMR from the earlier period to the most recent 20 years for the plants that remain in operation. The greatest changes occurred in the older plants; the leukaemia SMR for children aged 0–19 years rose 13.9%, from 0.986 to 1.123 ($P < 0.02$). Areas closest to the newer plants had a smaller increase of 9.4% (SMR from 0.897 to 0.981, not significant). For both groups of plants, the SMR rose more rapidly for the 10–19 age group compared with the 0–9 group, a pattern that is inconsistent with the Baker and Hoel findings. The areas near the closed plants experienced an insignificant 5.5% decrease in SMR, from 1.028 to 0.971. In the most recent two decades, a total of 1037 childhood leukaemia deaths occurred near the plants still operating, while 255 occurred near the closed plants.

Current (1985–2004) local childhood leukaemia mortality near older US plants still operating is above the US rate (SMR > 1.00), while mortality near newer plants is below the US (SMR < 1.00). While it is feasible that higher emissions of radioisotopes into the environment from older plants may account for the observed trends, caution should be used when interpreting the data. There may be demographic differences between the two groups that can include factors affecting mortality risk such as poverty, proximity to medical facilities and presence of other environmental pollutants. Prudence should also be used when reviewing results for the areas near closed reactors. It is possible that reduced emissions after closing are associated with reduced childhood leukaemia mortality, but other possible confounding factors should be considered.

The analysis is also affected by the time frames used in the early years after nuclear plant startup. Anywhere from 3 to 27 years after startup was used by the US National Cancer Institute in the earlier period, according

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Table 1. Change in Standard Mortality Ratio (SMR), childhood leukaemia; US nuclear plants started 1957–1981; startup–1984 vs. 1985–2004

Age (years)	SMR (deaths) Startup–1984	SMR (deaths) 1985–2004	% Change in SMR	
All plants still operating, startup 1957–1981 ($n = 39$)				
0–9	1.004 (639)	1.077 (504)	+7.3	$P < 0.24$
10–19	0.910 (516)	1.038 (533)	+14.1	$P < 0.04$*
Total 0–19	0.960 (1155)	1.055 (1037)	+9.9	$P < 0.03$*
Older plants still operating, startup 1957–1970 ($n = 12$)				
0–9	1.051 (487)	1.176 (292)	+11.9	$P < 0.14$
10–19	0.909 (351)	1.077 (283)	+18.5	$P < 0.04$*
Total 0–19	0.986 (838)	1.123 (575)	+13.9	$P < 0.02$*
Newer plants still operating, startup 1971–1981 ($n = 27$)				
0–9	0.880 (152)	0.964 (212)	+9.5	$P < 0.39$
10–19	0.913 (165)	0.996 (250)	+9.1	$P < 0.39$
Total 0–19	0.897 (317)	0.981 (462)	+9.4	$P < 0.22$
San Onofre plant, San Diego CA and Orange CA Counties, startup 1967				
0–9	1.080 (229)	1.305 (204)	+20.8	$P < 0.06$
10–19	0.880 (171)	1.242 (199)	+41.1	$P < 0.002$*
Total 0–19	0.984 (400)	1.269 (403)	+29.5	$P < 0.0004$*
All plants now closed, startup 1957–1981 ($n = 12$)				
0–9	1.015 (150)	0.962 (120)	–5.2	$P < 0.66$
10–19	1.043 (137)	0.980 (135)	–6.0	$P < 0.61$
Total 0–19	1.028 (287)	0.971 (255)	–5.5	$P < 0.51$

*Significant at $P < 0.05$.

to the plant. This could affect results, even though a standard of 20 years was used for the later period.

The plant with the largest local population is the San Onofre installation in southern California, located on the border of San Diego and Orange Counties. Results are also presented for this site in Table 1, and a significant increase in leukaemia SMR for children aged 0–9 and 10–19 years was observed. Areas near other individual facilities experienced many fewer deaths, and no changes achieved statistical significance.

Because of major therapeutic advances in the past several decades, the childhood leukaemia survival rate is one of the highest of any type of cancer in developed nations. The death rate has plunged while incidence has risen; in the USA, the childhood leukaemia mortality and incidence changes from 1975 to 2004 were –49.0% and +28.7% respectively. Currently, there are about seven newly diagnosed cases of childhood leukaemia each year for each death (Ries *et al.* 1975–2004). Analysis of recent childhood leukaemia mortality data near nuclear plants may reflect the efficacy of treatment as much as it does an outcome of radioactive exposures or other factors. While further study should include both incidence and mortality data, incidence of recent childhood leukaemia patterns near nuclear plants may provide more meaningful data. In addition, as cancer registries acquire data for longer periods, it would be helpful to continue examining temporal trends of this disorder near nuclear installations.

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JOSEPH MANGANO
Radiation and Public Health Project, New York, USA
JANETTE D. SHERMAN
Environmental Institute, Western Michigan University, Kalamazoo, MI, USA

APPENDIX

US nuclear plants started 1957–1981, used in Table 1, by startup date and open/closed status

Startup 1957–1970	Startup 1971–1981		Closed
Shippingport/Beaver Valley	Palisades	Hatch	Yankee Rowe
Dresden	Pilgrim	Peach Bottom	Big Rock Point
Indian Point	Quad Cities	Three Mile Island	Hallam
Fermi	Surry	Brunswick	Humboldt Bay
San Onofre	Turkey Point	Cook	Pathfinder
Ginna	Vermont Yankee	Salem	Haddam Neck
Nine Mile Point/Fitzpatrick	Browns Ferry	St. Lucie	LaCrosse
Oyster Creek	Fort Calhoun	Crystal River	Maine Yankee
Millstone	Oconee	Davis Besse	Zion
Point Beach/Kewaunee	Prairie Island	Farley	Rancho Seco
Robinson	Arkansas 1,2	North Anna	Trojan
Monticello	Calvert Cliffs	Sequoyah	Fort St. Vrain
	Cooper Station	McGuire	
	Duane Arnold		